Prediction of Retear after Arthroscopic Rotator Cuff Repair Based on Intraoperative Arthroscopic Images Using Deep Learning: A Novel Method of Retear Prediction

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INTRODUCTION:
It is challenging to predict retear after arthroscopic rotator cuff repair (ARCR). The usefulness of arthroscopic intraoperative images as predictors of the ARCR prognosis has not been analyzed. We suggest that tendon quality might directly influence the risk of retear, and arthroscopic imaging can be appropriate for determining tendon quality. Therefore, we used DL algorithms to predict retear based on arthroscopic images. We hypothesized that the intraoperative arthroscopic images could predict the retear with DL algorithms.
METHODS: In total, 1,394 arthroscopic intraoperative images were retrospectively obtained from 580 patients. Repaired tendon integrity was evaluated using magnetic resonance imaging (MRI) performed within 2 years after surgery. Images obtained immediately after ARCR were included. We used three DL architectures to predict retear based on arthroscopic images. Three pre-trained DL algorithms (VGG16, DenseNet, and Xception) were used for transfer learning. Training and test sets were split into 8:2. Three-fold stratified validation was used to fine-tune the hyperparameters using the training data set. The validation results of each fold were evaluated. The performance of each model in the test set was evaluated in terms of accuracy, area under the receiver operating characteristic curve (AUC), F1 score, sensitivity, and specificity.
RESULTS: In total, 1,138 and 256 arthroscopic images were obtained from 514 patients and 66 patients in the non-retear and retear groups, respectively. The mean age of the study participants was 61.59 years for the non-retear group and 64.92 years for the retear group, with a significant difference between the groups ($p<0.01$). The mean validation accuracy of each model was 83% for VGG16, 89% for Xception, and 91% for DenseNet. The accuracy for the test set was 76% for VGG16, 87% for Xception, and 91% for DenseNet. The AUC was highest for DenseNet (0.92); it was 0.83 for VGG16 and 0.91 for Xception. For the test set, the specificity and sensitivity were 0.93 and 0.84 for DenseNet, 0.89 and 0.84 for Xception, and 0.70 and 0.80 for VGG16, respectively.
DISCUSSION AND CONCLUSION:
The most important finding from the current study is that convolutional neural network (CNN) classifier algorithms predicted retear based on arthroscopic images with high accuracy without the analysis of demographic information or additional radiologic findings. The three CNN classifiers achieved AUC 0.8; the DenseNet model predicted retear and non-retear with an accuracy of 91% and AUC of 0.92. Our study shows the usefulness of arthroscopic images for the prediction of prognosis without the need to combine them with other factors.
Our results suggest that the postoperative prognosis can be determined based on the tendon status, thereby alleviating the need to evaluate the causes of retears. The newly developed tool allows objective communication regarding poor tendon quality and determines the risk of retears. This understanding allows the personalization of postoperative care, including the immobilization duration and rehabilitation protocol, and provides patients with appropriate caution. Furthermore, this prediction can be considered in the event of potential disputes concerning the surgeon’s responsibility following the occurrence of retears. Although retears can be asymptomatic initially, they can lead to negative long-term outcomes and the risk prediction of retear could be used to tailor the follow-up duration. Notably, a high probability of retear, as indicated by the algorithm, does not imply surgical failure or render the surgery unnecessary because retear is not the only important surgical outcome.
In conclusion, DL algorithms based on intraoperative arthroscopic images can predict retears after ARCR with high accuracy and without the analysis of other factors. The ability to predict retears may depend on the tendon’s quality visible on intraoperative arthroscopic images.